N88-14527

ATMOSPHERE DYNAMIC PROCESSES STRUCTURE AT 80-105 KM ALTITUDE

B. V. Kalchenko and A. N. Oleinikov

Institute of Radioelectronics
Kharkov, USSR

Determination of wind velocity by means of Doppler meteor radars is based on the assumption that an ionized meteor trail drifts together with the neutral atmosphere. From the Doppler frequency shift it is possible to estimate the radial velocity of the trail drift V_{Ri}.

Conversion of the recorded radial velocity to the true wind velocity vector in the given space region depends both on the radar technical parameters and the chosen atmospheric motion model. The best results can be obtained if the radar measures θ_i, the azimuth of the reflecting point i ε_i, the reflection point elevation angle and h_i, the altitude of the reflecting point on the meteor trail for every meteor trail. Such a radar has been used by the authors (ZHUKOV, et al., 1978).

The wind velocity vector can be represented by its projections i.e., by meridional, zonal and vertical velocity components.

$$\vec{W}(t,h) = \vec{i}V_N(t,h) + \vec{j}V_E(t,h) + \vec{k}V_H(t,h)$$

Theoretical data on the velocity of vertical movement of atmsopheric layers are contradictory (SEMENOVSKY, 1974; GUBIN V. I., 1972; KHANTADZE, 1979). In general, we shall consider models characterized by zero vertical velocity. Numerous experimental data obtained by different methods show the presence of significant vertical gradients in the horizontal wind dV_r/dh. Thus, the meridional and zonal components of wind velocity can be presented by the following formulae:

$$V_N(t,h) = V_{NO} + \frac{dV_N}{dh}(h_i - h_o);$$

$$V_E(t,h) = V_{EO} + \frac{dV_E}{dh}(h_i - h_o),$$

where V_{NO}, V_{EO} are mean values of the meridional and zonal wind velocity at the medium altitude h_o of a certain meteor measuring region.

The meteor zone is characterized by a wide wave motion spectrum and is generally turbulent. The spread of individual velocity values measured during an hour, has, characteristically, a standard deviation σ = 30 m sec^{-1}. Estimates of wind velocity are obtained using statistical methods. It is assumed in this case that during the averaged time (most commonly one hour) the parametres V_{NO}, V_{EO}, dV_N/dh, dV_E/dh and V_H do not change and characterize some mean value for the time Δt in the atmospheric layers located in the altitude interval Δh. The value of Δh is determined from measurement statistics. It is assumed that V_H does not change in the considered altitude region Δh.

When processing the observations made for December 13-27, 1983, acceptable intevals were Δt = 1 hour, Δh = 6 km, with aerials being directed northwards. In addition, the results for all the meteor echoes

were analyzed without separating them according to altitude. The average experimental altitude over the entire meteor zone was 92,5 km. In spaced six-kilometre intervals (84-90 km, 90-96 km and 96-102 km) the average altitudes were 87,3 km, 93,0 km and 98,5 km.

Fig. 1 shows the sliding average two day velocities of zonal, meridional and vertical wind in three altitude ranges. The data obtained show that the zonal circulation reversal began in the higher atmospheric layers first. The meridional and vertical velocities exhibit a tendency to inverse correlation, i.e., our results confirm the theoretical conclusions of GUBIN (1972) and KHANTADZE (1979).

Fig. 2 shows the day by day variations of the vertical gradient of the horizontal wind velocity in the zonal and meridional directions. Averaging over the whole of the meteor zone, the mean gradient of velocity in both directions amounts to 1 $msec^{-1}$ km^{-1} and testifies to the presence of a nine-day wave whose phases for the two directions differ by 56,6°. The gradient value reached about 8 $msec^{-1}$ km^{-1} when the height range was divided into six-kilometre intervals. The radar characterisitics insure IGW identification with the following limiting parametres: $\lambda_x \geq 100$ km, $\lambda_z \geq 8$ km, $T > 30$ min. In determining IGW parameters, the radio meteor observations undergo special processing, including spatial stratification of the meteor data, low and high frequency filtering of time series of horizontal wind velocity and spectral analysis. Identification of IGW oscillations is carried out from consideration of all of the above.

Using the above scheme, measurements over three intervals of meteor trails drift observations (December 17-19, 1978; July 23-August 2, 1982; December 13-27, 1983) have been processed.

In the meteor zone the spectra of meridional and zonal wind velocities were very unsteady both in time and in space. Several cases of a sharp change in the wind velocity spectrum above 90-92 km were observed. For most of the IGW the change of their amplitude with altitude, notwithstanding the general tendency for the amplitude increase, is oscillatory in character. Amplitudes of identified IGW fall within the limits of 5-30 m sec^{-1}, the mean value being 12-15 m sec^{-1}. The phase and altitude characteristics of IGW accompanied by a quasi-linear change of wave phase with altitude can be divided into three main types; increasing, decaying and broken. The phase changes with altitude and time of the waves indicates vertical wave energy propagation. The vertical wave length of over half of all the measured IGW varied within 8-30 km, the wavelength in 70% of the waves exceeding 20 km. Typical values of the meridional components of the horizontal wave length and the phase propagation velocity were 100-800 km and 20-140 m sec^{-1} respectively. Fig. 3 shows histograms of the distribution of frequency, meridional component amplitude, horizontal phase velocity, vertical wave length and the IGW vertical flux of energy.

Particularly noteworthy are cases of IGW behaviour at meteor heights revealed by the analyses of vertical profiles of wind velocity spectra and the wave amplitude and phase variations with altitude. These waves primarily decay, and are generated in the altitude interval under consideration.

Also observed were cases when the phase and amplitude of wind velocity distrubances with quasi-linear altitude change in the upper and lower

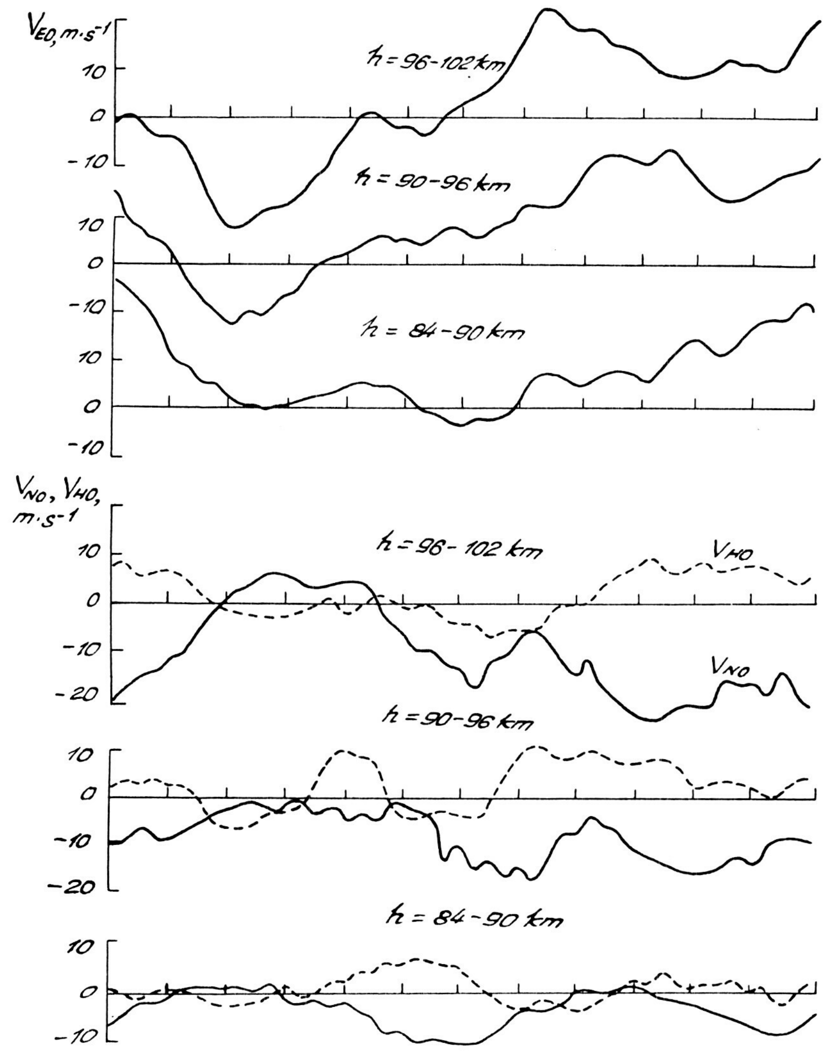

Fig. 1 Sliding two day mean velocities of zonal V_{EO}, meridional V_{NO} and vertical V_{HO} winds over Kharkov for December 13-27, 1983.

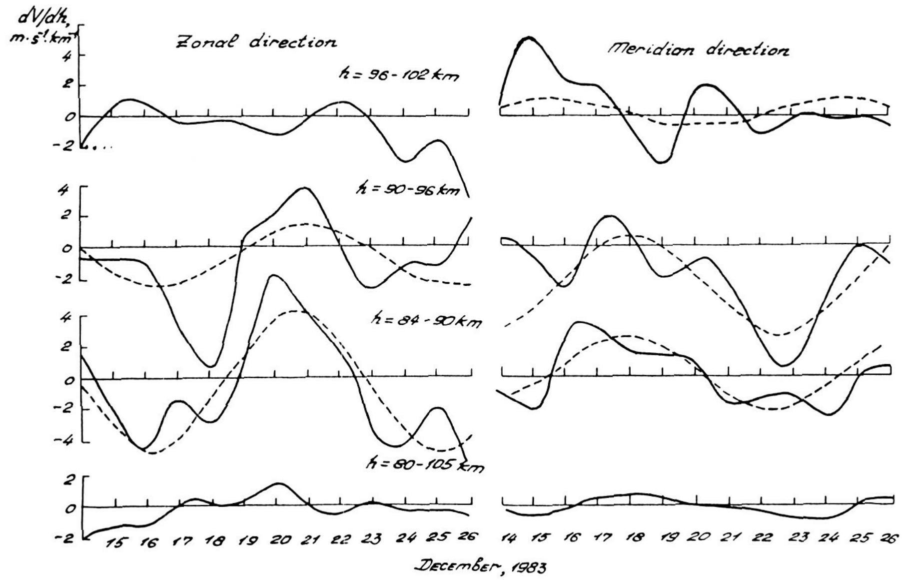

Fig. 2 Day-by-day variations of the vertical gradient of the horizontal zonal and meridional wind (——); the presence of a nine-day wave (- - -) is obvious.

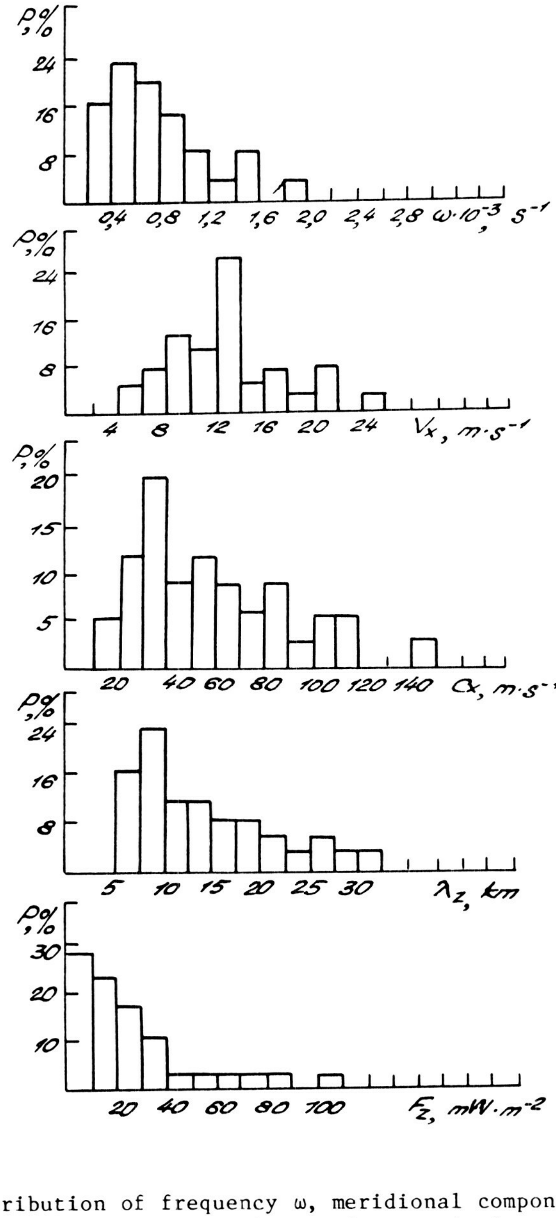

Fig. 3 Distribution of frequency ω, meridional component amplitude V_x, horizontal phase velocity C_x, vertical wavelength λ_z and the vertical flux of energy F_z of internal gravity waves in the meteor region over Kharkov, expressed as a percentage of occurrence.

meteor zone regions undergo a characterisitic disruption in middle altitudes. Such behaviour of phase and amplitude characteristics is evidence of wave-wave interaction.

The cases of IGW decay and generation described above are typical of the meteor zone as we have observed it.

References

1. Zhukov V. V., Oleinikov A. N., Oleinikov V. N., 1978, Automatic Goniometer, Communication II, Signals pre-processing, in Collection Radiotekhnika, Kharkov, Vol. 47, pp. 9-14.

2. Semenovski Yu. V., 1974, Theoretical estimate of wind vertical velocity in the meteor zone, Transactions of the Institute of Experimental Meteorology, Moscow, Iss. 2, 47, pp. 42-46.

3. Gubin V.I., 1972, On wind velocity components, in Metorologiya i Gidrologiya, Moscow, No. 7, pp. 3-6.

4. Khantadze A.G., 1979, On a mechanism of wind vertical velocity generation in ionsphere, in Geomagnetism i Aeronomiya, No. 4, Vol. 19.